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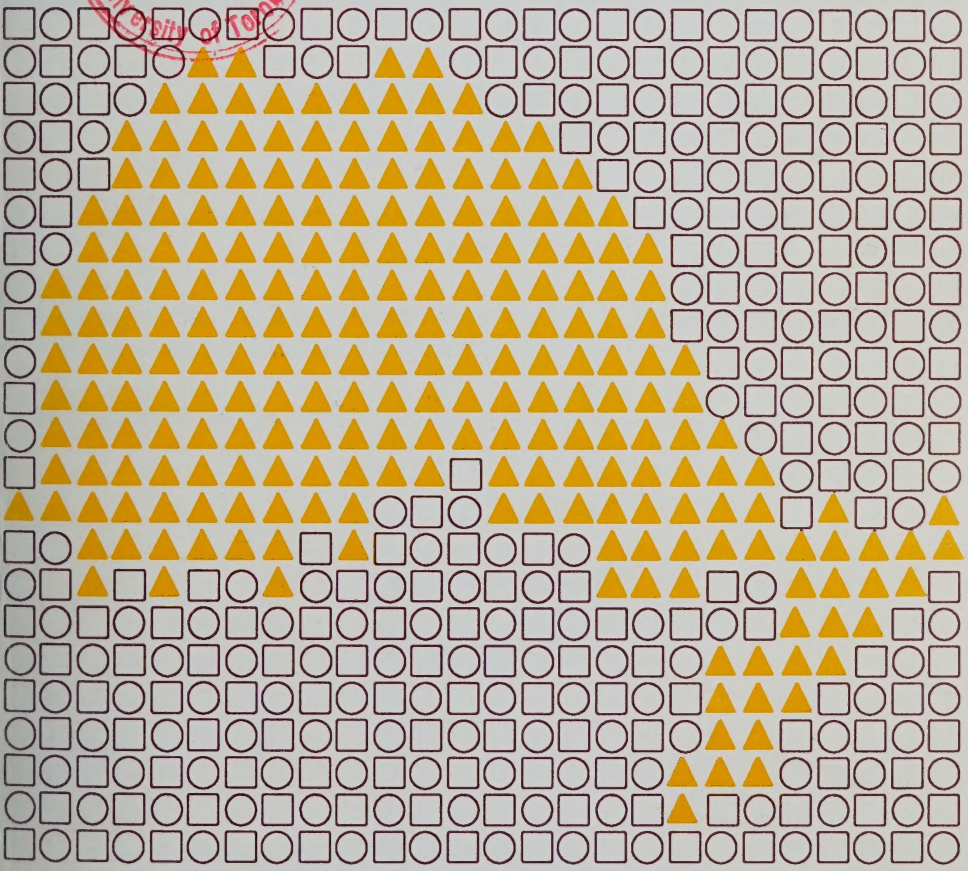
The Application of WHMIS in an Analytical Laboratory

Ontario's Occupational Health Resource Centres After 12 Years

Comparison of GC–FTIR and GC–MS Techniques for the Identification of Volatile Substances



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Occupational Health in Ontario

Volume 12, Number 1, Winter 1991

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The Application of WHMIS in an Analytical Laboratory

Summary

The WHMIS regulation was passed in the provincial legislatures of Canada to address the worker's right to know about the hazards and safe-handling practices concerning chemicals in use in his or her workplace. The application of this regulation poses a substantial problem for analytical laboratories. The experiences of the Occupational Health Laboratory of the Ministry of Labour are presented.

Key Words: **WHMIS, laboratory, MSDS, workplace labels, training**

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Introduction

The Workplace Hazardous Materials Information System (WHMIS) became a regulation under the *Occupational Health and Safety Act* effective October 31, 1988. As most readers know, it has provisions for worker education, for material safety data sheets (MSDSs) and for workplace labels. For the typical workplace with a relatively large amount of a few chemicals, the prospect of complying with WHMIS was not too daunting, and the steps taken to comply would not have been extensive. The problems faced by a typical analytical laboratory such as ours would, however, pose an enormous task. Three thousand or more containers of chemicals varying from small to modest amounts, many of which are rather obscure, can be housed in such a facility. The problem had to be faced in the most rational and effective way possible to effect compliance while avoiding being overburdened by the training, labelling and MSDS requirements. Our experiences are described below.

Designing the System

Since the potential impact was extensive, it became necessary to form a WHMIS committee consisting of all laboratory management staff to determine the problems and outline a course of action to present to the staff as a whole. From the intense discussions generated over the myriad situations with which our program would have to deal, it became clear that establishing the needs and future course of action was not going to be simple and straightforward. Review of the proposed regulation generated an abundance of questions as there was some degree of ambiguity in the written regulation. The information in Table 1 of the regulation was helpful in spelling out the tasks

that had to be performed, but was of no help in guiding us in how to complete them. It became obvious that no master plan was possible, and therefore we decided to proceed on an iterative plan where the solution to one problem would be used as insight to solve the next one. This process was slow and tedious, but in the end it provided a workable system that is effective and relatively inexpensive.

The laboratory, which had an existing chemical inventory system that recorded each chemical container in the building, its whereabouts and the mass or volume of chemical present, was in need of refurbishing since it did not include reference analytical standards (which would have to be included in the WHMIS program). Furthermore, the computer–based inventory had not been referenced against a manual inventory check of chemical holdings for some time. It was decided that, because of the large number of containers of chemicals in the lab, one person would be required to devote his or her full time to the WHMIS project. A request for contract help was submitted, and a chemical technician soon joined our staff. Once a planned course of action was decided upon, meetings of the WHMIS Committee were held to monitor the progress and proceed to subsequent steps.

The number of fields on the chemical inventory data base was expanded to provide the chemical name, date of receipt, a coded reference to supplier, a coded identifier for suppliers' safety data sheets, expiry date of the MSDS, CAS number, WHMIS classification codes and safe–handling codes. It was felt that such data would be extremely helpful and time–saving for all users of the inventory system.

Material Safety Data Sheets

During the early stages of implementation of the WHMIS program, we realized that it might be feasible and useful to develop a largely electronic MSDS data base system. The chemical inventory system was searched, and the major chemical suppliers to the laboratory were noted. Purchase of a number of electronic MSDS data bases from these suppliers seemed to be one easy administrative way to

maintain current and readily accessible MSDSs for the vast majority of chemicals. An MSDS data base from Sigma Aldrich, in compact disc format, was purchased, and we obtained a compact disc driver and a PC computer and printer. Thus, we had a supplier-specific source of MSDSs for a large portion of the chemicals in the lab as well as a source of MSDSs for most chemicals there, whether from Sigma Aldrich or not. This reveals a subtle but important requirement of the WHMIS regulation: an MSDS must be from the supplier of a chemical; a general purpose (i.e. generic) one is not adequate. The exception is the circumstance where a proper supplier-specific MSDS is unavailable, in which case the employer must create or supply an in-house MSDS. This is an all-too-common occurrence since in many cases chemicals have been in the lab for a long period of time (before MSDSs were available), they are rare, they were synthesized in the lab or the supplier no longer exists. Thus, where MSDSs were simply not available, employer MSDSs were generated from the data in the compact disc so that staff could use the chemicals. For chemicals purchased from suppliers other than Sigma Aldrich, specific MSDSs were available in paper format. MSDSs in both formats are coded on the inventory to provide quick reference on where to obtain a required MSDS.

Workplace Labels

Until this time, containers of chemicals had labels attached that typically contained the name of the substance and a container identification number. In addition, a colour-coded dot was applied to show the area of the lab within the building where the bottle normally was located. This code was used to ensure that a container remained within a small area of the lab and that anyone using the chemical knew where to return it. In addition, the same information, as well as purchase information, was available on the computer data base so that one could tell at a glance how much volume or mass was ordered and from which supplier.

The WHMIS regulation demanded an even more informative workplace label system, and the Joint Health and Safety Committee agreed to the following proposal. A label compatible with WHMIS requirements was purchased, onto which was printed the same information noted above along with an appropriate MSDS reference classification and safe-handling information. We were able to purchase rolls of stick-on labels that had the accepted pictogram for each of the classifications in WHMIS and appropriate symbols to represent eye protection, face protection, use in a fumehood only, respiratory protection and skin protection. Therefore, each container carried with it information sufficient for an employee to ascertain the hazard associated with the chemical, to adopt the required safe-handling practices, and to know the location of the MSDS material and where in the building the chemical ought to be stored. All of this information was stored on the computer-based chemical inventory and was available from a computer printout.

Additional Considerations

The process of ordering a chemical became more complicated, but eventually was worked out on the following principles. Any manager who wanted to order a chemical had to complete a WHMIS chemical safety inventory control form from the MSDS library. This form, which requested all relevant information for a proper WHMIS workplace label, was submitted with the purchase order to the purchasing staff. When the chemical was received, the clerk knew from the WHMIS chemical safety form what labels to put on the container. This labelling was completed *before* the chemical was allowed into the general lab area — a requirement of the WHMIS regulation.

The chemical inventory would not be complete without an effective system for removal of containers from the system once chemicals are used up. This was accomplished by providing a storage area for emptied and thoroughly cleaned-out containers. Once a week or so a clerk would remove from the inventory the registration number of any such

inventory the registration number of any such container, and once every few months each lab group was to spend a few minutes going through its stockpile of chemicals to make sure that what was present belonged there. If it didn't belong, the container was returned to its proper location.

A special problem arose for the large number of containers with small amounts of chemical in them (i.e. 10 to 100 grams). The bottles are much too small to accommodate a workplace label. We compromised by obtaining different sized resealable, hard-plastic containers into which the chemical containers could fit. The chemical inventory information was put on the chemical bottle itself, and this same information and the WHMIS information were put on the outer container. Reminders were provided through made-to-order WHMIS posters that indicated the meaning of the various pictograms used in the process. Staff could easily consult the posters, which were positioned throughout the lab, to refresh or clarify their knowledge as needed.

During this period of application of workplace safety labels, another complete chemical inventory was taken to ensure that there was a one-to-one match between the actual holdings of containers and the computer inventory. This provided a good opportunity to correct spelling errors and rectify any anomalies in the inventory, since every chemical had to be handled to affix the workplace labels. Any chemicals found that were absent from the inventory or for which there were no MSDS references were set aside while we obtained the necessary information. At this stage, some chemicals were found that were not being used, were unsuitable for use, were showing deterioration, and so forth; these had to be disposed of rather than being returned to the shelves. Where the chemical identification was questionable, the unknown chemical was analysed in our laboratory in a fashion similar to that used for unknowns received from workplaces. Following analysis, the chemical was labelled and returned for use in the lab or sent for disposal in the appropriate fashion.

Finally, as a last resort for chemicals where MSDSs could not be obtained, employer MSDSs were produced from whatever information could be obtained from in-house and external sources such as RTECS, Sax, Merck Index, CRC Rubber Handbook and so forth. Blank MSDS forms were obtained and used to record the information. Where no specific information was available for a chemical, professional staff made a best-educated guess through comparison with similar chemicals, which was entered into the safety data base.

Meanwhile, chemicals were arriving daily, and as part of our ongoing task we had to be sure to obtain supplier-specific MSDSs for them. Contact was made with the supplier companies to ensure the proper MSDSs were forwarded at the same time as the chemicals. For cases where the MSDS did not arrive, a system was put into place to request an MSDS from the supplier and to follow up as necessary.

Chemicals Shipped Out

The Occupational Health Laboratory is also composed of air-sampling technologists stationed in regional offices in the province. The lab in Weston supplies these technologists with whatever chemicals they need for their work. In order to meet the obligations that WHMIS imposes on suppliers, we had to produce suitable MSDSs for all air-sampling solutions and provide them to each regional office where chemicals may be stored or used. In consultation with the field technologists, these MSDSs were produced. All air-sampling solutions are now labelled with appropriate WHMIS and safety symbols.

The major task is now one of maintaining the system and monitoring it. This system cannot be allowed to deteriorate to any appreciable degree since the effort to catch up would be extreme. Fortunately, through a modest staff reorganization, the WHMIS maintenance duty can be assigned to one person. The lifespan of an MSDS is three years, and the computer system has been constructed to make known immediately to the operator when an

MSDS is about to expire. This procedure provides enough lead time for the WHMIS clerk to obtain a revised MSDS from the supplier (usually at cost). It is estimated that no more than one day per week is needed to maintain the system.

Training

The Occupational Health Laboratory staff received training for WHMIS in December 1988 and immediately thereafter began to implement the regulation within the workplace. This training included a full day of classroom seminars, group discussions and safety films. All aspects of WHMIS were dealt with at a level suitable for most work situations. The safety films used during the initial training were valuable because they helped emphasize the importance of the various WHMIS chemical hazard symbols.

Specific laboratory concerns were left to a separate half-day of WHMIS training by senior laboratory staff. During this training, the laboratory staff were instructed about the WHMIS data base created on our in-house computer system and the use of the WHMIS/CD-ROM/PC-based computer system, which is able to provide most MSDS information. Along with chemical labelling, the MSDSs provide the primary means for all staff to obtain health and safety, handling and clean-up information. Because of the large variety of chemicals used in a laboratory and their vast differences in properties and toxicities, it was felt that the training of all staff and the provision of accurate and easily accessible MSDSs offered the best route for satisfying WHMIS safety and training needs. A laboratory WHMIS information officer was designated as a contact person to address staff concerns or problems related to the WHMIS system.

On an annual basis, the corporate health and safety office contacts the joint committee to see if WHMIS training is in need of updating.

For those seeking additional information on WHMIS, an excellent source of information is the Ontario Ministry of Labour library at 400 University Avenue (tenth floor). WHMIS materials available

include: WHMIS manuals, legislation, MSDSs and information on workplace labelling and worker training.

Conclusion

The Occupational Health Laboratory now has a complete and accurate inventory of chemicals that has been greatly augmented to cater to the demands of WHMIS. The inventory system enables all order requests by laboratory staff to be checked to see if a chemical is already available in the laboratory. The paper MSDS that is received with the chemical is filed in the appropriate location, and the inventory system is updated as required. MSDSs are updated as their expiry dates come due. The workplace labels supply all the information required and are prepared and applied to the container before the chemical is released into the lab. Training requirements are reviewed annually with the Joint Health and Safety Committee to determine what additional needs have to be met.

Résumé

Le règlement concernant le SIMDUT a été adopté dans l'ensemble des assemblées législatives au Canada. Le règlement traite du droit qu'a le travailleur de s'informer sur les matériaux dangereux utilisés ainsi que sur les pratiques touchant la manipulation en toute sécurité des produits chimiques en usage dans son lieu de travail. L'application de ce règlement pose un problème considérable dans le cas des laboratoires d'analyses. Voici un exposé sur les résultats des expériences effectuées au laboratoire de santé au travail du ministère du Travail.

Ronald E.M. Lees, M.D., D.P.H., F.R.C.P.C.

Ontario's Occupational Health Resource Centres After 12 Years

Summary

Twelve years ago, the Occupational Health Resource Centres were formed in Ontario. Their educational, information and service activities have proved a valuable asset to occupational health and safety in the province. This article reviews the operations of these centres and documents the community services they provided during the past year.

Key Words: resource centres, community/ regional services, educational/information services

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Introduction

Twelve years ago, Ontario introduced a new approach to the delivery of occupational health and safety services by creating four occupational health resource centres. Established to coincide with the proclamation of the *Occupational Health and Safety Act, 1978* (the former Bill 70), the centres were based at four universities: Lakehead University (Thunder Bay), Queen's University (Kingston), the University of Waterloo, and the University of Western Ontario (London). In 1982 a fifth centre opened at Sudbury, under the joint interest of Cambrian College and Laurentian University.

At the time the 1978 Act was proclaimed, Ontario had insufficient resources to meet the requirements of the legislation. Whatever resources did exist tended to be centred in Toronto or connected with the large manufacturing and mining companies. Some of the province's universities had the personnel and were ideally situated geographically to allow for decentralization of available expertise and knowledge. The Government of Ontario provided a grant to allow the centres to be formed in the locations mentioned above. From the outset, the centres had a mandate to create, within their respective regions, a community resource for occupational health and safety education, information and consultation. Shortly after their inception, I wrote about the objectives and aspirations of the centres established under this unique concept of Ontario's Ministry of Labour.[1]

There were obvious disparities in terms of the population and territory serviced by the centres, and these differences have in part influenced the ways in which each centre has developed. There were differences too in the composition of the industrial

communities in each area, with forestry, for example, being concentrated in the Lakehead area and mining concentrated around Cambrian.

The centres were small in terms of number of people employed. Each centre had severe limitations on the expertise available, even allowing for the substantial body of technical and professional knowledge existing at the universities and colleges. Within a few years of their creation, the idea of networking the centres was developed by the directors, and today considerable sharing of resources is possible. Major policies are decided jointly at regular meetings of the directors, and several joint educational projects have been mounted. As well, some expensive analytical laboratory instruments located at one centre can be accessed by the others.

Throughout their existence, the centres have been accessible to any institution, industry, trade union or worker — indeed, to any member of the community. Tables 1 and 2 illustrate the wide-ranging nature of the clientele. It has also been centre policy to remain

Table 1 **Training Courses Run by Centre, 1989–90**

Institution/ Organization	Number of Courses	Number of Participants
Technical	46	1053
Trade Union/ Worker Centre	4	95
Company	104	1824
Government	4	80
Local Authority	9	978
Open Courses	20	603
TOTAL	187	4633

Table 2 **Information Inquiries: All Centres 1989–90**

Source	Number	Response	
		Written	Verbal
Individuals	3657	1839	1818
Trade Union	13	3	10
Government Agencies	612	70	542
Hospitals/ Health Services	236	26	210
Companies	762	101	661
Education Agencies	486	32	454
Not Classified*	1438	587	851
TOTAL	7204	2658	4546

*These responses represent one centre that did not break down requests by source.

non–partisan in philosophy and action, functioning as honest broker in a field where polarization of interests occurs quickly and often. (Although it has been easy to function in such a manner, being seen to function this way is not always so simple a matter, especially because management usually pays the bill for the work done.) It is policy to work through, or with, health and safety committees wherever they exist, and there are very few recorded instances of that route having been refused by contracting companies.

Initially, the centres were totally grant–supported, but that period was short–lived. Currently the centres receive a small amount of funding from the Ministry of Labour to provide educational and information services to the community. Consultation and service activities are charged to clients at market rates, the proceeds from these helping to meet staff salaries and subsidize educational services.

Staff and Facilities

Collectively, the centres employ 49 persons (Table 3). Each centre has an analytical laboratory either as a unit of it or as an adjunct facility. The most specialized and best equipped laboratory is at the University of Western Ontario, and the other centres use it frequently for asbestos analysis. There is, throughout the network, a good range of portable field equipment for use 'on site' by the occupational hygienists and technicians.

Table 3 **Staff 1989–90**

Category	Admin. /Clerical	Pro.	Tech.	Train./ Student	Total
Full-Time	6	13	5		24
Part-Time	9	6	3	7	25
TOTAL	15	19	8	7	49

Services

The scope and volume of services provided to the community and the types of institutions that request them are discussed in the following sections. Apart from verbal requests for information and use of the libraries, services carry a fee, although they are free to those unable to meet the costs. Thus, all workers, service groups and voluntary organizations as well as students have access to them.

Educational Services

These fall into five categories: public courses on matters covered by regulations (e.g. WHMIS, designated substances); technical courses required by workers (e.g. environmental monitoring, noise and hearing conservation); specialized courses required by service providers (e.g. audiometry, lung-function testing); assistance to institutions offering occupational health and safety courses (e.g. community colleges; and industry- or sector-specific workshops arranged for individual companies or institutions (e.g. materials handling for employees of education boards).

Table 1 above is a breakdown of the 187 courses and workshops provided by the centres during the fiscal year 1989–90. The 4,633 persons who attended these included health and safety representatives, industrial workers, health inspectors, school board custodians and teachers, supervisors, nurses and general employees of companies from both management and labour.

Some of the courses are fairly intensive, extending over several days, although most are one day only. The topics vary according to both the needs of the contracting groups and the industrial composition of the area. For example, mining subjects are concentrated in Sudbury and forestry or pulp and paper topics in Thunder Bay. Other topics are common to all centres — WHMIS training, chemicals handling, hearing conservation, dust control, respirator use, ergonomics, measuring the quality of the work environment and so forth.

The training requirements for health and safety committee members that will be introduced in Ontario under Bill 208 will not duplicate the offerings of the centres. The curriculum content of the centres' courses and workshops will still be required to ensure that within each workplace there are members who have more than a rudimentary knowledge of occupational health. The general training required by the new legislation and the 'secondary' education offered by the resource centres should be regarded as complementary.

Because of location, although not a requirement for ministry support, each centre provides teachers and courses for students of its university or college. (These programs are not included in Table 1, which shows only courses provided for clients or conducted as open courses run by the centres.)

Information Services

Very few sources of accurate occupational health and safety information are available for the concerned individual, the non-unionized worker, the small employer or the local group of interested persons. Similarly, there are few places one can turn to for

advice on career opportunities, toxic materials handling, possible occupational risks or dealing with a workplace concern.

Providing an information service is a time-consuming business that rarely demands any fee. The centres' policy is to charge only for a written reply. The diversity of requests requires an information officer to have a high level of technical expertise as well as familiarity with electronic data bases and their access. Each centre maintains a small but adequate library of books, journals, reports and government publications (provincial, federal and international). In addition, all centres have electronic on-line access to a number of data bases and copies of the 'info' discs of the Canadian Centre for Occupational Health and Safety (CCOHS). All the information officers agree that the interpretation of data is the most important part of their work, as raw data on its own is often of little value to a client.

During the most recently recorded 12-month period, the centres collectively dealt with 7,204 requests for information on occupational health and safety matters (Table 2) above. Of these, 2,658 required written replies.

Examination of Table 2 provides interesting insight into the characteristics of those seeking information about some aspect of occupational health and safety. One centre does not break down information requests by source, but we can assume the distribution is similar to the others. Of the 5,766 requests whose source can be identified, more than 60 per cent came from individual workers or members of the public and a surprising 23 per cent (1,334) came from government agencies or institutions (hospitals and health care institutions being included as government-funded operations). A relatively few requests, 13 per cent, came from companies, and almost none (0.2 per cent) from trade unions. These last-named groups have their own organized sources of information.

As legislative controls on occupational health and safety in Ontario have increased in number and complexity, the demand for readily accessible information centres has grown. Within their regions, the resource centres have obviously been able to establish credibility over the 12 years of their existence and are providing a valuable service to the people and communities of the province. The data in Tables 1 and 2 substantiate the quantity of the centres' contribution to both occupational health and safety education and information dissemination in Ontario; the continued and increasing demand for their services must attest to the quality.

The demand for information services will almost certainly grow in the years ahead, particularly while verbal advice is free. The Canadian Centre for Occupational Health and Safety has recently been forced to eliminate its free on-line inquiry service. The user fee now in place has reportedly reduced the number of inquiries, resulting in a 66 per cent drop in on-line computer connections to the CCOHS.[2] The loss of free access to the central CCOHS will undoubtedly increase the volume of inquiries to the resource centres and to other provincial sources of occupational health and safety information.

Conclusion

Continentally, if not internationally, the establishment of university- and college-based regional resource centres was a unique approach to the provision of expert occupational health and safety services in Ontario. Existing organizations and Ministry of Labour resources were insufficient in 1978 to meet the demand for skilled assistance for education and services that the new *Occupational Health and Safety Act* would create. As the legislation changes and awareness of health and safety issues grows, the demand for valid, unbiased information continues to increase. The brief examination of a recent year's activities by the linked resource centres suggests the province's experiment of 12 years ago was justified. The development of five such centres at regional institutions with concentrations of expertise in science and education

has given Ontario a network of occupational health and safety resources that may be the envy of other jurisdictions.

Résumé

Il y a douze ans, on assistait à la création des Centres de ressources en santé au travail en Ontario. Leurs fonctions éducatives, informatives et les services qu'ils fournissent se sont avérés un atout considérable au plan de la santé et de la sécurité au travail dans la province. Le présent article passe en revue les activités des centres et fournit des renseignements sur la nature des services communautaires qu'ils ont fournis au cours de la dernière année.

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Comparison of GC–FTIR and GC–MS Techniques for the Identification of Volatile Substances

Summary

This article highlights the differences between GC–FTIR and GC–MS, evaluates the advantages of each analytical technique and demonstrates their usefulness on several specific compounds.

Key Words: Fourier transform infrared, mass spectroscopy, identification, volatile substances

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Introduction

Gas chromatography (GC), and especially capillary gas chromatography, is the most commonly used analytical technique for rapid identification and quantitation of volatile substances. The gas chromatograph separates the components of a mixture, and the identification is achieved by the retention time of each individual component of that mixture, using a series of reference standards. These reference standards have to be run under identical conditions each time an analysis is carried out.

For many practical purposes, identification of the separated components of a mixture is possible by retention time only. The complex nature of real-life samples and the large number of co-eluting organic compounds, however, necessitate on occasion the confirmation of each component, usually by a spectroscopic method. The two most common confirmatory techniques used for this purpose are infrared (IR) spectroscopy and mass spectroscopy (MS).

Although the common term in these two analytical techniques is 'spectroscopy', they are totally different both in principle and in instrumentation.

The purpose of this article is to highlight these differences, to evaluate the advantages of each of these approaches and to demonstrate their usefulness on several specific compounds. All of these comparisons, however, are restricted to the comparison of GC–FTIR (Fourier transform infrared) and GC–ion trap mass spectroscopy, since these were the instruments available to produce the analytical results in our laboratory.

Theory of Infrared Spectroscopy

Both infrared (IR) and Fourier transform infrared (FTIR) spectroscopy produce the same end result: a distinct molecular fingerprint called the infrared spectrum.

These two approaches differ only in the method by which the infrared spectrum is obtained, a subject not within the scope of this study. Both IR and FTIR spectroscopy belong to the vibrational family of molecular spectroscopy. Both are absorption–spectroscopic techniques, meaning that the spectrum is obtained by absorbing certain frequencies of light from the electromagnetic radiation that is used for excitation. The loss of some frequencies of light from the otherwise continuous source produces on the chart paper a pattern of peaks and valleys, which we call the spectrum.

To understand the underlying principle behind vibrational spectroscopy, it is important to emphasize that all molecules are made up of atoms held together by chemical bonds. These atoms, and groups of atoms within a more complex molecule, all vibrate with respect to each other and rotate more or less freely in space. The motions, according to quantum theory, are excited in discrete energy steps, or quanta.

The so called 'infrared' region of the electro–magnetic radiation (the mid–infrared from 2.5 to 25 μm, or 4,000–400 cm^{-1} wavenumbers) can be considered to affect only the vibrational energy levels of the irradiated molecules. Rotational transitions are seen only when smaller molecules in the vapour phase are examined, and they appear as fine structure associated with the vibrational absorption bands. These are usually superimposed on the basic vibrational spectrum.

Without going deeper into the theory of characteristic frequencies, which constitutes the essence of infrared spectroscopy, one can state the *basic rule*: the stronger the bond between the atoms of the molecule and the smaller the vibrating atoms, the higher the frequency of vibration. Each absorbed frequency corresponds to a molecular vibration and

results in an absorption band in the infrared spectrum.

Characteristic absorbtion frequencies exist for practically all important functional groups (e.g. alcohols, phenols, ketones, esters, carboxylic acids, aldehydes) or chemical bonds and structures, which are summarized in correlation charts and tables as well as in infrared atlases, all available in the scientific literature.

The advantage of infrared spectroscopy to the scientist is that the IR spectrum is interpreted in terms of the same concepts he or she uses in studying chemical properties. The characteristic absorption bands in the spectrum provide valuable information regarding the chemical nature of the *intact molecule* and its functional or reactive groups. This is in contrast to mass spectroscopy, where structural information is obtained from evaluating *molecular fragments*.

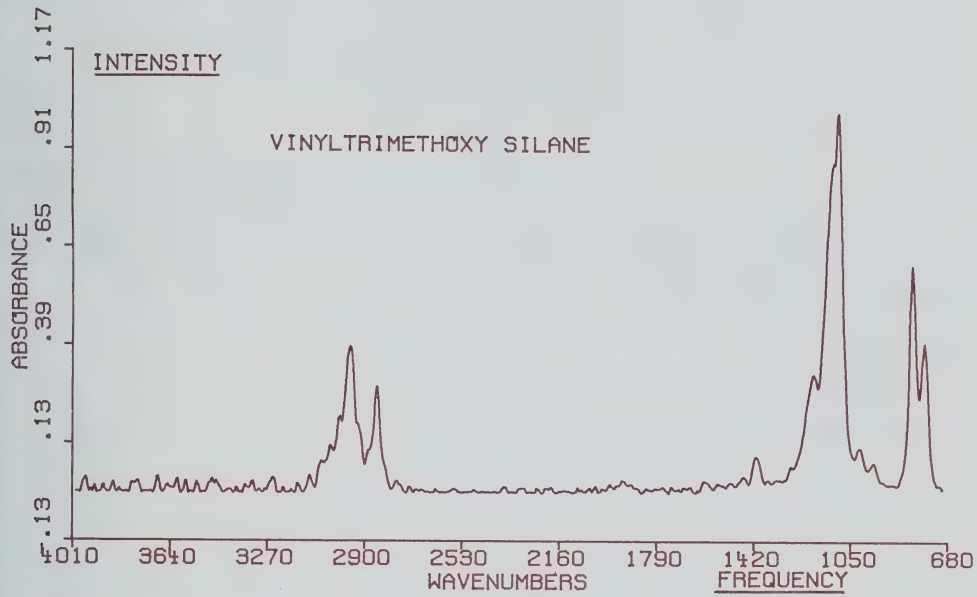
The special importance of infrared spectroscopy in structural analysis is best understood by realizing that the infrared spectrum (Figure 1) is the *most characteristic physical property* of a chemical compound. It is actually a *multipoint* physical property, which contains a wide variety of information about the composition and structure of an organic molecule. Apart from providing a rich source of information about the molecule by indicating the presence or absence of characteristic functional groups, the IR spectrum can be regarded as a 'molecular fingerprint'. This explains the extensive use of infrared spectroscopy for 'finger-printing', or identifying, chemical substances.

Theory of Mass Spectroscopy

While infrared spectroscopy provides an infrared spectrum, which is an intensity versus frequency-of-light plot, the mass spectrum is an intensity versus mass correlation, displaying masses of the ionized molecule and its fragments.

Mass spectroscopy is a destructive analytical technique, and in principle it is not related to other spectroscopic methods, which are based on the excitation of molecules by electromagnetic radiation.

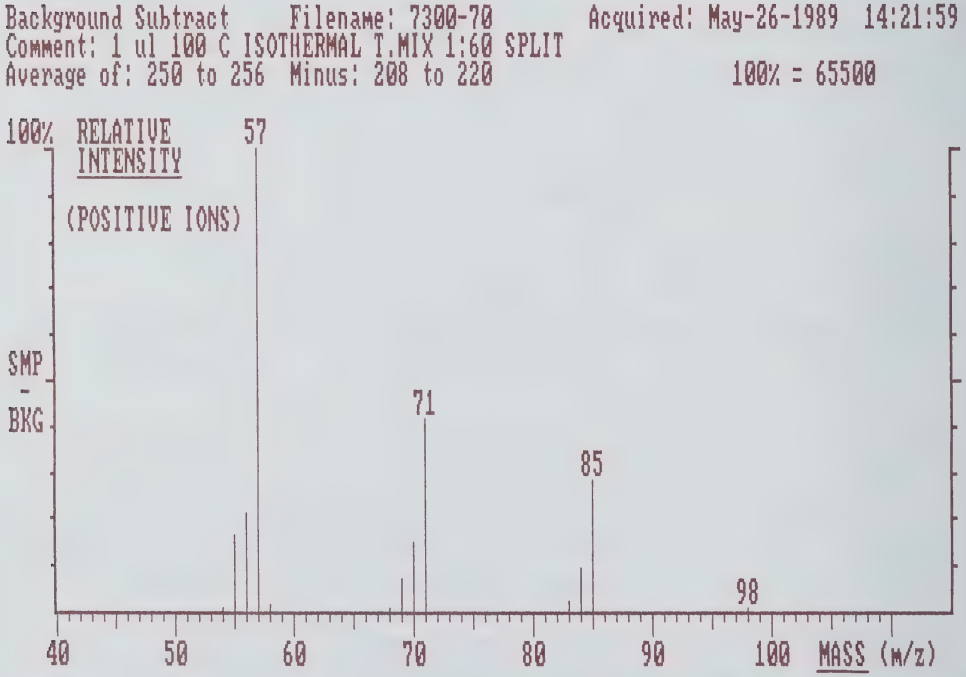
Figure 1 **An Infrared Spectrum (Intensity vs. Frequency Plot)**



In mass spectroscopy, a stream of vaporized sample molecules is bombarded in a vacuum with a beam of monoenergetic electrons to form a variety of products. As a first product of the interaction between the neutral sample molecule and the electron beam an excited molecule, the molecular ion ($M^{+\cdot}$), is formed by the expulsion of one electron from the original molecule. Depending on the instability of the molecular ion and the structure of the original molecule (bond strength, steric factors, and so forth), further breakage of the molecular ion takes place immediately, producing a series of fragments with differing masses. This rupture of the molecule is largely reproducible and depends mostly on the energy of the incident electron.

In the most common form of mass spectrometry, all the *positive ions* pass through a mass analyser and reach an ion detector with time delays proportional to the masses of these ions. If the relative abundance of these ions is displayed on the Y–axis, and the actual masses of the respective ions (in atomic mass: amu units) on the X–axis, a so–called 'mass spectrum' is obtained (Figure 2).

Figure 2 **Mass Spectrum of an Aliphatic Hydrocarbon (Intensity vs. Mass Plot)**



The mass spectrum is also characteristic of the structure of the molecule. Since the instrumental running parameters, and even the type of mass spectrometer, have some effect on the fragmentation pattern — especially on the relative intensity of the fragment ions — a mass spectrum is never as reproducible as the infrared spectrum, which is the fingerprint of the intact molecule. In any case, the rupture pattern, or mass spectrum, is unique to the chemical under study and is largely reproducible if the same instrument settings are used.

In spite of this instrument-dependence of mass spectrometry, MS techniques are widely used for the identification of unknown substances. There are two main reasons for this: (1) MS is more sensitive than IR or even FTIR; and (2) GC–MS techniques were developed earlier than GC–FTIR. Consequently, the majority of validated methods (NIOSH, EPA, and so forth) are based on GC–MS whenever the matrix is too complex for identification by GC retention time alone.

Comparison and Discussion

Both GC–FTIR and GC–MS provide a valuable tool for the identification of volatile substances in complex mixtures, and both techniques are used by the Ministry of Labour's Occupational Health Laboratory (OHL).

Since reliable results with both FTIR and MS require pure analytes to start with, GC (i.e. capillary gas chromatography) serves mainly as a powerful separation technique to separate the individual components of mixtures. The GC retention times of the separated components, however, provide additional information when the spectra of certain components give ambiguous results.

The actual identification in both types of analysis is done by spectroscopic techniques, mostly by computer-assisted searches of the infrared and mass spectra.

Both GC–FTIR and GC–MS are extensively used in our laboratory for the identification of volatile components of unknown or not completely known bulk material samples.

The main limitation of FTIR analysis, the lower sensitivity (compared with MS), has seldom been a problem, since bulk material samples are normally available in quantities sufficient for analysis, and per cent levels of components are sought. Traditionally, bulk sample analyses were carried out by IR or FTIR techniques because the infrared spectrum facilitates the recognition of functional groups present in the unknown molecule.

Naturally, there is no single analytical technique that could be applied in all cases to solve a particular

problem. The identification of unknown volatiles is no exception to this rule. Both GC–FTIR and GC–MS have their own advantages and their own limitations. Fortunately, the two analytical techniques complement each other. Therefore, carrying out both analyses can give us more complete results than doing analysis by only one method.

A very good and simple example to demonstrate this is the analysis to identify the thermal decomposition products of a phenolic resin. On heating a particular phenolic resin in a closed vial to 175°C, only water and ammonia were detected by GC–FTIR analysis in the headspace vapours. The same headspace vapours analysed by GC–MS displayed only one peak, which was identified as phenol.

The contradiction can be explained easily, if one understands the limitation of the two techniques. As mentioned earlier, the main drawback of IR or FTIR methods is the relatively low sensitivity. At 175°C the phenol concentration was so low in the headspace that it could be detected only by GC–MS analysis. When the experiment was repeated at 220°C, the phenol peak appeared in the GC–FTIR run too (Figure 3), owing to the increased phenol concentration in the heated vial. The water and ammonia, however, were not detected by GC–MS either at 175° or at 220°C, since scanning for masses below 29 amu (atomic mass unit) is not recommended in general because of large interference peaks from atmospheric gas molecules.

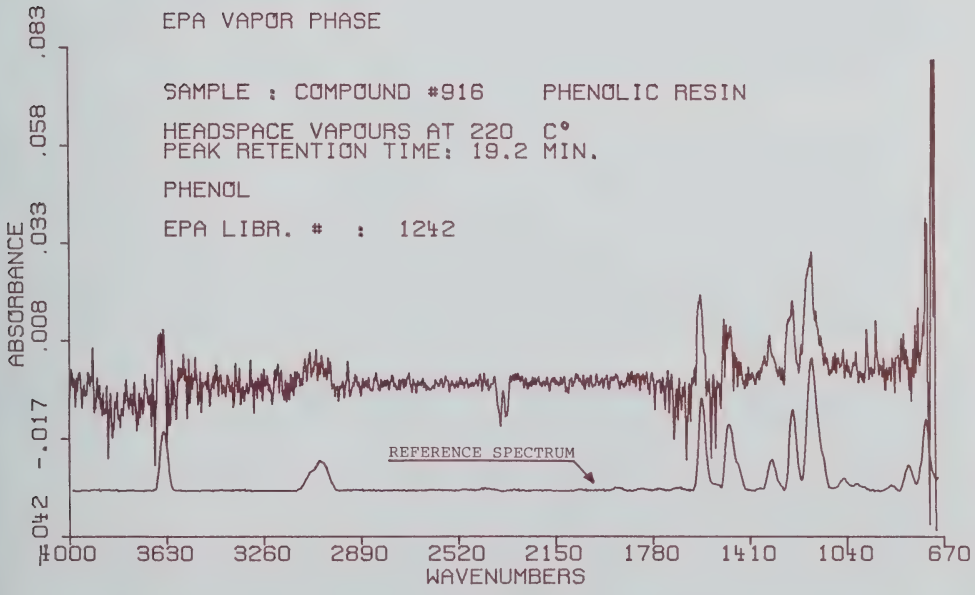
The major difference between the FTIR and MS techniques are summarized in Table 1 and are discussed below.

The first difference between the two techniques lies in the size of the analyte molecule. Generally speaking, the IR spectrum is independent of the molecule's size. With increasing molecular weight, however, compounds with the same functional group (e.g. alcohols) exhibit little differences in their IR spectra. As a result, the IR or FTIR technique is better suited for the identification of lower molecular weight substances.

Table 1 **Differences Between GC–FTIR and GC–MS Techniques**

	GC–FTIR	GC–MS
molecular size	better for low MW cpds.	better for high MW cpds.
functionality	group specific	less specific
destructivity	non–destructive	destructive
sensitivity	less sensitive (ng)	very sensitive (pg)
isomers	different IR spectra	similar MS spectra
usefulness	general scanning	target analysis

Figure 3 **A Trace of Phenol Detected at 220°C by GC–FTIR**



Fortunately, mass spectroscopy is more reliable for the differentiation and identification of higher molecular weight compounds, and therefore the two analytical techniques complement each other.

As far as the functionality of the analyte molecule is concerned, FTIR is a more reliable technique for identification, since the IR spectrum is generally highly group specific. That means the presence or absence of functional groups can be easily established by manual evaluation or by computer searches of the IR spectra of unknown substances. On-line identification, or the establishing of the chemical class of a compound by MS only, is more difficult, since the mass spectrum is less specific for functional groups than is the IR spectrum. This is the main reason for the preferential use of GC-FTIR for the identification of volatile substances whenever the lower sensitivity of the FTIR analysis is not a limiting factor.

IR or FTIR analysis is also non-destructive, while MS analysis is inherently destructive. The high energy electron bombardment fragments the organic molecules during the analysis. It is evident that evaluations based on spectra obtained from the intact molecule are usually more reliable than those obtained by molecular fragments. This is the main reason that the IR spectrum of the compound is independent of the instrument on which the spectrum was taken. This is not true for mass spectra, which are known to be instrument-dependent. Thus, ion trap mass spectrometry produces somewhat different fragmentation patterns from those obtained by conventional (magnetic sector, quadruple, and so forth) MS instruments. Certain compounds (e.g. aliphatic amines, alcohols, esters, ketones) are particularly sensitive to the instrumental settings, making GC-MS identification of these compounds, without derivatization, particularly difficult and unreliable.

The greatest difference between GC-FTIR and GC-MS analyses is certainly the sensitivity. Mass spectrometry is 100 to 1,000 times more sensitive than FTIR, even though the sensitivity gap between

these two techniques is decreasing. With the introduction of matrix isolation (MI) GC–FTIR and quite recently with the so–called Tracer (BIO–RAD trademark) system, the sensitivity of FTIR is rapidly approaching that of GC–MS analysis. As a matter of fact, the sensitivity of MI–GC–FTIR surpasses the sensitivity of GC–MS in special chemical classes. But these new FTIR techniques carry a substantially higher price tag, and their introduction to the OHL is not imminent. Therefore, whenever the presence or absence of an organic trace component has to be established, MS is the preferred method of analysis.

Generally speaking, FTIR is suitable for the differentiation of isomers, since all structural isomers (e.g. ortho–,meta– and para–xylenes) exhibit distinctly different IR spectra. Differentiation of isomers by MS alone is not possible. For positive identification, one must supplement the mass spectra with retention time data.

Conclusions

As far as the application of the two techniques is concerned, GC–FTIR is more suitable for general scanning for unknown volatiles, especially for the analysis of bulk material samples, while GC–MS has a definite advantage for target analysis of organic compounds.

This article has highlighted the application of both GC–FTIR and GC–MS to the analysis of bulk materials. The use of both techniques provides more information than that of either alone. Therefore, an increasing number of laboratories are using directly linked gas chromatography–Fourier transform infrared–mass spectrometry (GC–FTIR–MS) systems.

Résumé

Le présent article met en évidence les différences qui existent entre un chromatographe en phase gazeuse avec specrographe infrarouge par transformée de Fourrier (GC–FTRI) et un chromatographe en phase gazeuse avec spectroscopie de masse (GC–MS), évalue les avantages de l'une et l'autre de ces techniques d'analyse et montre leur utilité au plan de plusieurs combinaisons particulières.

Recent Publications Available from the Ministry of Labour

Support Literature

Mining Health and Safety Hazard Notices:

- Blasting Lines and Electrical Fault Currents, May 1990
- High Voltage Starter, January 1990
- Wood Stove Tanks, February 1990

Identifying Causative Factors and Effective Strategies to Reduce Occupational Back Injuries: A Review Paper, Ergo System Canada Ltd., March 1990

How Bill 208 Affects You — pamphlet (available also in French)

For further information, contact:

Information and Administrative Services
Edit and Control Section
(416) 326–7744

News and Notes

New Association of Occupational Health Laboratories

The Occupational Health Laboratory of the Ministry of Labour has initiated the formation of an association of laboratories performing analyses related to occupational health monitoring.

This association hopes to provide proficiency testing programs, technology transfer and assistance in the collection and analysis of clinical, air and bulk samples associated with worker health and safety in the province.

Laboratories that have not yet attended any of the meetings but wish to get involved should contact the following for more information:

Mark A. Nazar Ph.D., ROH, C.Chem.,
Occupational Health Laboratory,
101 Resources Rd.,
Weston, Ontario
M9P 3T1
(416) 235-5958

The 1st National Conference on Occupational Safety and Health, Hamilton, Ontario

March 11-13, 1991

Federal Labour Minister and Minister of State (Transport) Jean Corbeil announced that the first National Conference on Occupational Safety and Health (OSH), sponsored by Labour Canada, will be held on March 11, 12 and 13, 1991, at the Hamilton Sheraton Hotel in Hamilton, Ontario. This conference will promote an exchange of views and ideas between various economic partners on the future of occupational safety and health in Canada and internationally.

The National Conference on OSH will address current major safety and health issues in the workplace and those of the next 20 years. Prominent speakers from Canada and other countries will discuss issues such as the world of work and changes in the 21st century; the international perspective of OSH in the '90s; the work force, its composition, concerns, expectations and possible OSH implications; the cost implications of OSH; and the role of management, employees and government in the future of OSH activities.

Discussions are aimed at senior management representatives from business, organized labour, governments and academia. During the conference, an OSH trade exhibit will be held at the Hamilton convention Centre, adjacent to the Hamilton Sheraton Hotel.

Enquiries should be addressed to:

Francyne Rivest (819)994–2238
Pierre Rousseau (819)953–4194

IDSP Report on Asbestos and Cancer

In April 1990, the Industrial Disease Standards Panel released the Second Report to the Workers' Compensation Board on Certain Issues Arising from the Report of the Royal Commission on Asbestos. The second report suggests eligibility rules for asbestos–related cancers and includes a review of the epidemiological literature on occupational asbestos exposure up to August 1988.

The Majority Report

The Majority Report recognizes a probable connection between asbestos exposure and cancer of the trachea, bronchus, lung, gastrointestinal tract (oesophagus, stomach, colon and rectum) and laryngeal cancer. It suggests that these cancers be placed in Schedule 3 of the *Workers' Compensation Act*, with eligibility rules as shown in Table 1.

Table 1	Suggested Eligibility Rules	
Cancer	Occupational Exposure Period	Latency
Trachea, bronchus and lung	at least 2 years before 1975 or 5 years between 1975 and 1983, or 2.5 X the time before 1975 plus the time between 1975 and 1983.	at least 10 years
Oesophagus, stomach, colon and rectum	at least 10 years before 1975	at least 20 years
Laryngeal	at least 10 years before 1975	at least 15 years

The exposure criteria are based on the repeated or constant actual exposure or risk of exposure to asbestos, irrespective of the fibre type or concentration. The Majority Panel does not want these rules to be treated inflexibly, since shorter exposure times and shorter latency times than those listed in Table 1 have been associated with increased risk of cancer in asbestos epidemiological studies. The Panel recommends that the WCB review its 'interpretation and application of the benefit –of– doubt provision' because it feels that the WCB has been too restrictive in its interpretation of a 'reliable history ' of exposure to asbestos for asbestosis and mesothelioma. The Panel recommends that ' where any doubt exists as to whether the claimant has established his or her case, the Board shall resolve such doubt in favour of the client.'

The Minority Report

The Minority Report concurs that there is a probable connection between cancers of the trachea, bronchus, lung, oesophagus, stomach, colon, rectum and larynx and occupational exposure to asbestos. It therefore recommends that these cancers and exposure to asbestos be placed into Schedule 3 of the *Workers' Compensation Act,* and that these cancers be deemed to be due to occupational exposure to asbestos, unless the contrary is proved.

There are several reasons for the rejection of the eligibility rules proposed by the Majority Panel. The Minority Report does not consider that the case–by–case assessment of those workers who fall just short of the eligibility rule will lighten the burden–of–proof requirements of the workers. It contends that exposure levels may have been and still may be higher than those required in the legislation. Because the relationship between asbestos and lung cancer is 'best described by a linear non–threshold model', the Minority Panel would require no minimum exposure, since any exposure could theoretically increase the risks of asbestos–related cancers. The Panel finds that the latency times chosen are too long, because the epidemiologic studies cited use the time from first exposure to mortality as the latency period, although workers should be eligible for compensation upon diagnosis of cancer, which may occur an average of 18 months before death for patients with lung cancer, and much longer for those with GIT cancer. In addition, two studies showed excesses of lung cancer prior to 10 years of exposure to asbestos.

Implications

The difference between the Majority and Minority Panel opinions have important implications for the future of occupational diseases compensation. Since exposure to asbestos is associated with the six cancers outlined in this report, it is recommended that these cancers and exposure to asbestos be compensable. However, the two approaches diverge at this stage.

The Majority Panel sets out specific guidelines, based on the statistical results of epidemiological studies, which must be fulfilled before a cancer is deemed to be of probable occupational origin. The Minority Panel would not entrench a minimum exposure or latency period into the legislation, because, like the majority, it regards the relationship between asbestos and lung cancer as a linear non–threshold dose–response model. However, by leaving the exposure undefined, the field of potential candidates for compensation would increase, particularly for a relatively common cancer such as

lung cancer. The problem is that asbestos is not the only etiological factor associated with lung cancer, and there has been widespread exposure to asbestos in the workplace. The non-threshold approach would open up the possibility of a claim being filled by a person who smoked and who was exposed only once, in a non-fixed occupation such as professional renovation. Thus, although the conventional approach may under-compensate, the alternative may over-compensate.

Although this is a compensation issue, it raises questions regarding the process for setting standards for carcinogens in the workplace.

Y. Shirtcliffe

Occupational Health and Safety Information

Did you know that the Canadian Centre for Occupational Health and Safety (CCOHS) offers a free, confidential inquiries service? It's available on a toll-free line across Canada.

Ask us about:

- Computer terminals
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- Health and safety committees
- Shift work
- Work and pregnancy
- Workplace chemicals
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- Safe lifting

CCOHS also offers:

- Publications
- Data bases
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If you have a question or require further information, contact:

Inquiries Service,
Canadian Centre for Occupational Health and Safety
250 Main Street East,
Hamilton, Ontario
L8N 1H6
Telephone: (416) 572–4400
Toll-free: 1–800–263–8466
Fax: (416) 572–4500

Ontario Ministry of Labour, Occupational Health and Safety Division, Facts and Figures, (Prepared by Strategic Policy and Analysis Unit)

Inspection Data

	Number of Workplaces			
	Mining	Industrial	Construction	Total
1989–90	7,188	150,000	21,585	179,000
1988–89	7,105	150,000	26,156	183,000
1987–88	6,958	150,000	22,269	179,000
1986–87	6,795	150,000	21,399	178,000
1985–86	6,842	150,000	16,849	174,000

	Number of Workers			
	Mining	Industrial	Construction	Total
1989–90	49,195	3,500,000	311,000*	3.9 million
1988–89	49,532	3,500,000	309,800*	3.9 million
1987–88	47,372	3,500,000	305,000*	3.8 million
1986–87	45,501	3,200,000	257,000**	3.5 million
1985–86	45,557	3,200,000	248,000	3.5 million

* Total labour force

** Employed labour force

	Number of Inspectors			
	Mining	Industrial*	Construction*	Total
1989–90	47	157	113	317
1988–89	44	165	104	313
1987–88	46	166	109	321
1986–87	42	131	88	261
1985–86	42	132	69	243

* Includes operational managers

	Number of Inspections			
	Mining	Industrial	Construction	Total
1989–90	4,335	25,446	40,559	70,380
1988–89	4,062	29,119	45,890	79,071
1987–88	4,976	24,611	39,790	69,377
1986–87	5,548	26,268	49,014	80,830
1985–86	5,111	41,628	46,552	88,691

	Total Investigations			
	Mining*	Industrial	Construction	Total
1989–90	2,513	6,048	3,093	11,654
1988–89	3,563	6,458	3,539	13,564
1987–88	4,010	5,896	3,283	13,189
1986–87	4,182	5,932	3,098	13,212
1985–86	2,097	5,081	1,980	9,878

* As of 1989–90, the Mining Branch no longer reports the number of accidents investigated (except for fatal accidents) but only reports hours spent on investigations

	Accidents Investigated			
	Mining*	Industrial	Construction	Total
1989–90	n/a	763	1,051	n/a
1988–89	3,099	835	1,355	5,289
1987–88	3,493	944	1,377	5,814
1986–87	3,618	998	1,416	6,032
1985–86	1,554	874	838	3,266

* As of 1989–90, the Mining Branch no longer reports the number of accidents investigated (except for fatal accidents) but only reports hours spent on investigations

	Number of Fatalities Investigated			
	Mining	Industrial	Construction	Total
1989–90	11	43	33	87
1988–89	13	50	41	104
1987–88	19	36	39	94
1986–87	10	33	41	84
1985–86	14	42	29	85

	Number of Complaints Investigated			
	Mining	Industrial	Construction	Total
1989–90	170	1,521	1,998	3,689
1988–89	160	1,523	2,142	3,825
1987–88	131	1,467	1,866	3,464
1986–87	186	1,560	1,638	3,384
1985–86	151	1,525	1,106	2,782

Refusals to Work Investigated				
	Mining	Industrial	Construction	Total
1989–90	20	342	11	373
1988–89	17	610	1	628
1987–88	17	409	1	427
1986–87	32	411	3	445
1985–86	29	344	7	380

Other Investigations				
	Mining*	Industrial	Construction	Total
1989–90	420	3,379	—	3,799
1988–89	271	3,440	—	3,711
1987–88	350	3,040	—	3,390
1986–87	336	2,930	—	3,266
1985–86	349	3,016	—	3,365

* Unusual occurrences investigated

Number of Orders Issued				
	Mining	Industrial	Construction	Total
1989–90	3,825	37,026	38,808	79,659
1988–89	4,378	37,961	48,165	90,504
1987–88	5,195	28,494	32,022	65,711
1986–87	4,333	36,889	24,508	65,730
1985–86	3,605	49,269	23,507	76,381

Number of Stop Work Orders Issued*				
	Mining	Industrial	Construction	Total
1989–90	89	1,600	2,048	3,737
1988–89	96	1,657	2,321	4,074
1987–88	132	1,135	1,507	2,744
1986–87	87	1,431	1,040	2,558
1985–86	188	1,645	560	2,393

* Included in total orders issued

Appeals Against Orders: 1985–89			
	Appeals Received	Formal Decisions Rendered	Settled/ Withdrawn
1989	123	27	96
1988	166	23	143
1987	124	30	94
1986	130	11	119
1985	103	4	99
Total	646	95 (15%)	551 (85%)

Appeals Against Orders: Formal Decisions Rendered – 1980–89*	
Allowed	17 (15%)
Allowed in Part	22 (19%)
Dismissed	77 (66%)
Total	116 (100%)

* Figures are based on a calendar year

Prosecution Data

	Total Charges Laid			
	Mining	Industrial	Construction	Total
1989–90	125	412	1,062	1,599
1988–89	154	533	1,377	2,064
1987–88	59	665	729	1,453
1986–87	28	448	637	1,113
1985–86	16	297	478	791

	Prosecutions			
	Mining	Industrial	Construction	Total
1989–90	14	104	396	514
1988–89	15	149	346	510
1987–88	12	176	229	417
1986–87	7	114	170	291
1985–86	5	75	168	248

	Number of Convictions			
	Mining	Industrial	Construction	Total
1989–90	11	80	280	371
1988–89	11	102	274	387
1987–88	8	110	192	310
1986–87	3	65	334	402
1985–86	3	56	334	393

Cases Completed and Outcome

		Completed	Convictions	Success Ratio
Mining	1989–90	14	11	79%
	1988–89	15	11	73%
	1987–88	12	8	67%
	1986–87	7	3	43%
	1985–86	5	3	60%
Industrial	1989–90	104	80	77%
	1988–89	149	102	68%
	1987–88	176	110	63%
	1986–87	114	65	57%
	1985–86	75	56	75%
Construction	1989–90	396	280	71%
	1988–89	346	274	79%
	1987–88	229	192	84%
	1986–87	170	143	84%
	1985–86	168	140	83%

Fines

	Mining	Industrial	Construction	Total
1989–90	$100,000	$590,000	$1,496,804	$2,186,804
1988–89	82,123	460,550	811,045	1,353,718
1987–88	93,000	397,982	417,105	824,387
1986–87	8,000	290,954	299,171	598,125
1985–86	12,000	148,700	277,509	438,209

Fines Against Employers/Supervisors/Workers

	Employers		Supervisors		Workers	
	No. Fined	Average Fine	No. Fined	Average Fine	No. Fined	Average Fine
1989–90	389	$5,667	132	$901	28	$329
1988–89	336	3,712	154	620	34	321
1987–88	269	3,200	91	550	33	350
1986–87	211	2,600	56	460	215	90
1985–86	158	2,400	54	670	229	100

WCB Basic Claims Statistics

Total For All Industrial Sectors, Ontario, 1985–89

Injuries	1985	1986	1987	1988	1989*
Total claims (000s)	426.9	442.1	469.7	489.8	475.0
Lost-time injury claims (000s)	188.5	203.2	209.2	215.2	207.0
LTIs total claims (%)	44.1	46.0	44.5	43.9	43.6
LTI frequency rate (per 1,000 workers)	43.1	44.9	44.6	44.3	41.8
Total workdays lost (millions)	6.3	6.9	6.9	6.7	8.4
Deaths					
Total Fatalities (including deaths of gold miners with lung cancer)	209	221	253	320	253
Fatality rate (per 100,000 workers)	4.8	4.9	5.4	6.6	5.1
Costs					
Benefits paid out ($ billions)	1.1	1.2	1.5	1.6	1.8
Assessments ($ billions):	1.3	1.6	2.0	2.3	2.2
Schedule 1 employers					

* 1989 data are preliminary

Lost-time Injury Rates by Sector (Per 1,000 Workers Employed)			
	Mining	Industrial	Construction
1985	88.2	36.1	64.6
1986	87.9	38.1	77.2
1987	83.1	38.1	64.4
1988	57.4	37.5	60.8
1989	52.8	35.5	53.3

Five Most Common Types of Injuries in Ontario Workplaces (as Per Cent of Total Claims)					
	1985	1986	1987	1988	1989
Sprains, strains	47.9%	48.9%	48.7%	49.5%	50.0%
Contusions	21.3%	20.9%	20.3%	20.7%	19.4%
Cuts, lacerations, open wounds	12.7%	12.8%	12.9%	12.6%	11.8%
Fractures	4.4%	4.1%	4.2%	3.9%	3.9%
Scratches, abrasions	3.3%	3.4%	3.3%	3.2%	2.7%
Proportion of all claims	89.6%	90.1%	89.4%	89.9%	87.8%

Five Most Frequently Injured Body Parts (Per Cent of Total Claims)*					
	1985	1986	1987	1988	1989*
Back	28.1%	27.4%	26.7%	27.1%	29.0%
Fingers	12.2%	12.0%	12.1%	11.9%	11.4%
Multiple Parts	6.8%	6.8%	6.7%	6.6%	7.6%
Knees	5.4%	5.3%	5.3%	5.3%	5.1%
Hands	5.1%	5.0%	5.1%	5.2%	4.8%
Proportion of all claims	57.6%	56.5%	55.9%	56.1%	57.9%

* Based on first payment compensation claims

Resources: Staff and Budget

Activity	1990/91 Printed Estimates $000s	Strength* as of June 1990
Program Administration**		
Assistant Deputy Minister	665.1	3
Executive Director	217.9	6
Program Analysis and Evaluation	472.8	6
Info. and Admin. Services	2,028.2	27
Prevention and Promotion (incl. $4,053.5 T.P.)	5,455.0	19
Construction Health and Safety	10,174.0	128
Industrial Health and Safety	16,099.5	239
Mining Health and Safety	6,770.0	87
Health and Safety Support Services	16,177.5	231
Research and Regulations	3,301.2	33***
Mine Rescue Training	1,585.7	11
Total	66,134.4	790

* Classified staff/filled positions

** Program Administration does not include ACOHOS ($461,500), Science Policy Adviser ($225,200) and Bill 208 held back ($2.5 million)

***Does not include policy staff transferred to Policy Branch

Book Review

Laboratory Biosafety Guidelines

Medical Research Council of Canada and Laboratory Centre for Disease Control

Health Protection Branch, Health and Welfare Canada, 1990.

These guidelines are a revision and an expansion of the Medical Research Council's 1977 and 1980 *Guidelines for the Handling of Recombinant DNA Molecules and Animal Viruses and Cells*. The focus is on the safe handling and storage in research laboratories of micro-organisms and other infectious agents that are pathogenic to humans. The guidelines are contained in a 63-page document that is divided into five chapters and three appendices. The introduction, which contains the historical background of these guidelines, is followed by a short chapter on the general safety practices and requirements for any laboratory handling and storing infectious or toxic agents.

The third chapter focuses mainly on the classification and containment of microbiological agents pathogenic to humans or animals. It includes a partial list of pathogens as classified according to the four recommended risk groups, and a discussion on the considerations and basis for evaluating the health risks of such agents in research and development. This chapter contains several important changes from the previous guidelines: less emphasis is placed on the health risks and containment requirements of recombinant DNA techniques, genetic manipulation, or cell cultures; the suggested classification scheme is revised to include not only animal viruses, but also other microbial pathogens; and the containment levels have been reduced from six to four in order to maintain consistency with the risk groups and to conform to levels recommended in the U.S. and U.K. guidelines. This chapter also discusses the acts and legislation in Canada that apply to the importation and transportation of infectious agents.

The last two chapters describe the physical and operational requirements of each containment level,

presenting in detail the elements in the laboratory designs necessary to achieve these requirements. The information is well organized and easy to follow.

In conclusion, this document is a good reference on laboratory safety practices and on the risks of different biohazardous materials. The discussion in these areas is, however, not as detailed as in a similar reference guide, *Biohazardous Guide*, produced by the American Industrial Hygiene Association (AIHA). It is also useful as a general reference for a system of classifying many micro-organisms pathogenic to humans or animals and for the typical safety practices used for the handling and storage of such agents in a *research* laboratory. It is especially handy for reviewing the recommended containment requirements and laboratory designs and equipment necessary for the handling and storage of these biological agents. This document is recommended as a useful addition to other references for laboratories developing and implementing guidelines on the use of biohazardous materials.

Copies may be requested from the Office of Biosafety, Laboratory Centre for Disease Control, Tunney's Pasture, Ottawa, Ontario K1A 0L2 (telephone: (613) 957-1779).

Jason Tung

Coming Events

February 26 – March 1, 1991	Society of Toxicology — Annual Meeting. DALLAS, TEXAS, U.S.A. For further information, phone: (202)293–5935
March 4 – 7, 1991	Toxic Metal Compounds (interrelation between chemistry and biology). LES DIABLERETS, SWITZERLAND. For further information, contact: Dr. Ernest Merian, Im Kirsgarten 22, CH–4106, Therwil, Switzerland.
March 5 – 7, 1991	Conference on Advanced Composites. SAN DIEGO, CALIFORNIA, U.S.A. For further information, contact: Conference on Advanced Composites, ACGIH, 6500 Glenway Ave., Building D7, Cincinnati, OH, U.S.A., 45211–4438.
March 6 – 8, 1991	Advances in Controlled Clinical Inhalation Studies: 3rd Inhalation Symposium. HANOVER, GERMANY. For further information, contact: Prof. Dr. Med. U. Mohr, Hanover Medical School of Experimental Pathology, Konstanty–Gutschow–Str. 8, D–3000, Hanover 61, Germany. Telephone: 49 511 532 4520/22.
March 11 – 13, 1991	Workplace Safety and Health: The 21st Century. HAMILTON, ONTARIO, CANADA. For further information, contact: Labour Canada, Workplace Safety and Health: The 21st Century, c/o Burson–Marsteller, 1100–155 Queen St., Ottawa, Ontario, Canada, K1P 9Z9. Telephone:(613)953–2996, FAX: (613)238–4740.

March 21 – 22, 1991	Occupational Safety and Health Symposium on Biotechnology. MONTREAL, QUEBEC, CANADA. For further information, contact: Mr. Pierre Delorme, Labour Canada, 237 Argyle Ave., Ottawa, Ontario, Canada, K2P 1B8. Telephone: (819) 953–0238, FAX: (819) 997–1664.
April 2 – 5, 1991	1991 International Symposium on Radon and Radon Reduction Technology. PHILADELPHIA, PENNSYLVANIA, U.S.A. For further information, contact: Timothy M. Dyess, U.S. Environmental Protection Agency, AEERL/Radon Mitigation Branch, MD–54, Research Triangle Park, NC, U.S.A., 27711.
April 9 – 12, 1991	1991 BOHS Conference. NOTTINGHAM, ENGLAND. For further information, contact: BOHS, 1 St. Andrew's Place, Regent's Park, London, NW1 4LB, U.K. Telephone: 07/486 4860, FAX: 071/224 2576.
April 15 – 17, 1991	Rehabilitation West — The Disabled Young Adult. Australian College of Rehabilitation Medicine, 11th Annual Scientific Meeting. PERTH, WESTERN AUSTRALIA. For further information, contact: Mrs. Anne Worden, ACRM, 55 Charles St., Ryde, NSW 2112, Australia. Telephone: (02) 807 6688.
April 16 – 19, 1991	The Ergonomics Society: 1991 Annual Conference. SOUTHAMPTON, ENGLAND. For further information, contact: Dr. E.J. Lovesey, Lynton, Horseshoe Lane, Ash Vale, Aldershot, U.K. Telephone: 0252 24461, ext. 2501/2656.

April 23 – 25, 1991	Verein Deutscher Ingenieure: Carcinogenic Substances in the Environment. MANNHEIM, GERMANY. For further information, contact: VDI ABT, To Graf–Recke–Str.84, D–400 Duesseldorf 1, Germany. Telephone: 49 0211 6214 302, FAX: 49 0211 6214 575.
April 24, 1991	Fourth International Conference on Slipping, Tripping and Falling Accidents. LONDON, ENGLAND. For further information, contact: Mrs. C. Barlow, Conference Secretary, Robens Institute, University of Surrey, Guildford, Surrey, U.K., GU2 5XH. U.K.
April 30 – May 3, 1991	Rehabilitation: Restoring Purpose, Place and Pride. National CRS Conference 1991. MELBOURNE, AUSTRALIA. For further information, contact: The Manager, Commonwealth Rehabilitation Service, GPO Box 9848, Melbourne, Victoria 3001, Australia. Telephone: (03) 604 4264, FAX: (03) 602 4962.
May 18 – 24, 1991	American Industrial Hygiene Conference, SALT LAKE CITY, UTAH, U.S.A. For further information, contact: American Industrial Hygiene Conference, PO Box 8390, 345 White Pond Dr., Akron, OH, U.S.A., 44320
June 2 – 6, 1991	European Society of Toxicology: 31st Congress. MAASTRICHT, THE NETHERLANDS. For further information, contact: Dr. Ettlin, Secretary, European Society of Toxicology, Sandoz Ltd., Building 881, CH 4002 Basel, Switzerland. Telephone: 41 061 62 56 47, FAX: 41 061 61 00 02.

June 12 – 14, 1991	Hazardous Materials Management Conference '91 (HAZMAT International '91). ATLANTIC CITY, NEW JERSEY, U.S.A. For further information, contact: Tower Conference Management Co., 800 Roosevelt Rd., Building E, Suite 408, Glen Ellyn, IL, U.S.A. 60137–5835. Telephone: (708) 469–3373, FAX: (708) 469–7477.
June 16 – 21, 1991	Seventh International Conference on AIDS. FLORENCE, ITALY. For further information, contact: c/o NIOSH/OPPE, Building 1, Room 3040, Mailstop D29, U.S.A.
June 16 – 21, 1991	Health — United Effort: 14th World Conference on Health Education. HELSINKI, FINLAND. For further information, contact: The Finnish Council for Health Education, Karjalankato 2 C 63, SF–00520, Helsinki, Finland.
June 18 – 20, 1991	International Symposium on Performance of Protective Clothing. MONTREAL, QUEBEC, CANADA. For further information, contact: Dr. J. Lara, IRSST, Boul de Maisonneuve Ouest, Montréal, Québec, Canada, H3A 3C2. Téléphone: (514) 288–1551, FAX: (514) 288–9632
July 8 – 11, 1991	Fourth International Symposium on Neurobehavioral Methods and Effects in Occupational and Environmental Health. TOKYO, JAPAN. For further information, contact: Professor Shunichi Araki, M.D., President of the Symposium, Department of Public Health, Faculty of Medicine, University of Tokyo, 7–3–1 Hongo, Bunkyo–ku, Tokyo, 113, Japan. Telephone: 81(3) 812–2111, ext. 3494, FAX: 81(3) 816–4751.

July 15 – 20, 1991	11th Congress of the International Ergonomics Association. PARIS, FRANCE. For further information, contact: Secretariat IEA '91, Laboratoire d'Ergonomie, 41 rue Gay–Lussac, Paris 75005, France.
July 18 – 22, 1991	Pioneering a Safer World: 10th International System Safety Conference, System Safety Society, North Texas Chapter. DALLAS, TEXAS, U.S.A. For further information, contact: 10th International System Safety Conference Committee, P.O. Box 292455, Lewisville, Tex., U.S.A., 75029–2455. Telephone: (214) 492–9005.
August 13 – 15, 1991	Work in the 1990s: International Symposium on Future Trends in the Changing Working Life. HELSINKI, FINLAND. For further information, contact: Work in the 1990s Symposium, c/o Institute of Occupational Health, Suvi Lehtinen, Topeliuksenkatu 41 a A, SF–00250 Helsinki, Finland.
September 2 – 6, 1991	HCI International '91: Fourth International Conference on Human–Computer Interaction. STUTTGART, GERMANY. For further information, contact: Fraunhofer–Institute for Industrial Engineering, HCI '91 Sectretariat, Nobelstrasse 12, D–7000, Stuttgart 80, Germany.
September 4 – 8, 1991	Healthy Buildings — IAQ '91. WASHINGTON, D.C., U.S.A. For further information, contact: Jim Norman, Manager of Technical Services, ASHRAE, 1791 Tullie Circle NE, Atlanta, GA, U.S.A., 30329

September 10 – 12, 1991	Eighth International Symposium, Epidemiology in Occupational Health, PARIS, FRANCE. For further information, contact: Convergence 120, Avenue Gambetta, Paris 75020, France.
September 16 – 18, 1991	Safety and Health Throughout the Planning and Construction Process: 13th International Colloquium. International Section of the ISSA for the Prevention of Occupational Risks in the Construction Industry. BRUSSELS, BELGIUM. For further information, contact: Conference Secretariat, NAVB–CNAC, Boulevard Poincare, 70, B–1070, Brussels, Belgium.
September 16 – 20, 1991	Ventilation '91 — 3rd International Symposium on Ventilation for Contaminant Control, CINCINNATI, OHIO, U.S.A. For further information, contact: ACGIH, 6500 Glenway Ave., Building D7, Cincinnati, OH, U.S.A., 45211–4438 Telephone: William Kelley (513) 661–7881.
September 16 – 20, 1991	Seventh international Symposium on Inhaled Particles. EDINBURGH, SCOTLAND. For further information, contact: Dr. A. Robertson, Organizing Secretary, British Occupational Hygiene Society, Seventh International Symposium on Inhaled Particles, Institute of Occupational Medicine, Roxburgh Place, Edinburgh, Scotland, EH8 9SU
October 15 – 17, 1991	Profit from Prevention. International Occupational Health and Safety Convention 1991. MELBOURNE, AUSTRALIA. For further information, contact: Sue Wood & Associates, 1st Floor, 387 Malvern Rd., South Yarra, Victoria 3141, Australia. Telephone: (03) 824 0022, FAX: (03) 826–0771.

October 21 – 23, 1991	Third International Symposium on Education and Training in Occupational Health, and 11th UEOEH International Symposium. KITA-KYUSHU, JAPAN. For further information, contact: Univ. Occupational Environmental Health, Toshiteru Okubo, M.D., Yahatanishi-ku, Kita-Kyushu 807, Japan.
October 29 – November 1, 1991	International Symposium on Air Sampling Instrument Performance. Applications, Technology, Criteria and Standards. RALEIGH, NORTH CAROLINA, U.S.A. For further information, contact: Air Sampling Instrument Performance Symposium, c/o ACGIH, 6500 Glenway Ave., Building D7, Cincinnati, OH, U.S.A., 45211-4438.
November 1991	International Society of Exposure Analysis Annual Conference. ATLANTA, GEORGIA, U.S.A. For further information, contact: Gerry Akland (MD-75), Environmental Protection Agency, Research Triangle Park, NC, U.S.A., 27711. FAX: (919) 541-7588.
November 1991	First International Symposium on Global Warming and Human Health. KHARTOUM, SUDAN. For further information, contact: Professor Dr. Moneim Attia, IHSRC, PO Box 2020, Khartoum, Sudan.
November 10 – 14, 1991	American Public Health Association: 119th Annual Meeting. ATLANTA, GEORGIA, U.S.A. For further information, contact: Bob Johnson, APHA, 1015 15th St. NW, Washington, D.C., 20005, U.S.A. Telephone: (202) 789-5672, FAX: (202) 789-5661.

November 17 – 20, 1991	Asian Association for Occupational Health: Asian Conference on Occupational Health. BANGKOK, THAILAND. For further information, contact: Prof. Malinee Wongphanich, Occuapational Health Dept., Building 3, Faculty of Public Health, Mahidol University, Bangkok, Thailand. Telephone: 662 246 1258, ext. 259/260/261, FAX: 662 246 7765.
May 17 – June 2, 1992	Eighth World Congress of the International Radiation Protection Association. MONTREAL, QUEBEC, CANADA. For further information, contact: Dr. J.P. Gauvin, 2155 Rue Guy, Bureau 820, Montréal, Québec, Canada, H3H 2R9.
May 24 – 27, 1992	Futuresafe 92: Operating Safe Environment. National Safety Council of Australia. ADELAIDE, SOUTH AUSTRALIA. For further information, contact: NSCA Congress & Exposition, c/o International Convention Management Services, P.O. Box 8102, Hindley St., South Australia, 5000. Telephone: (08) 210 6776, FAX: (08) 212 5101.
September 18 – 20, 1992	Harvard School of Public Health: Indoor Air Quality. BOSTON, MASSACHUSETTS, U.S.A. For further information, contact: Office of Continuing Education, Dept. B, Harvard University School of Public Health, 677 Huntingdon Ave., Boston, MA, U.S.A., 02115.

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